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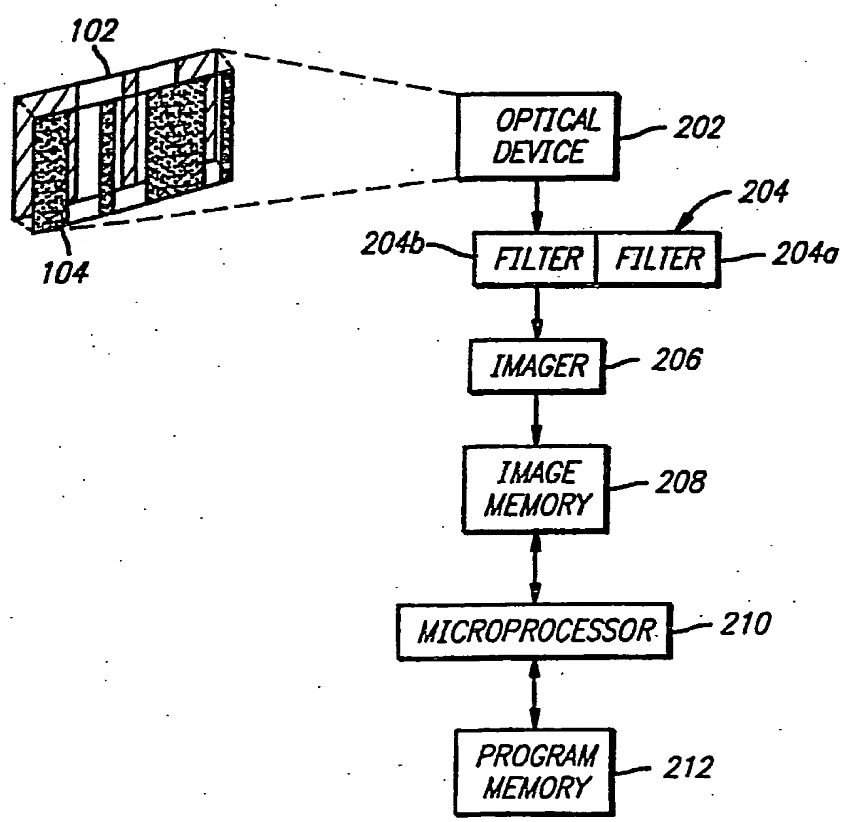
(54) Title: MULTI–COLORED SYMBOLOGY METHOD AND APPARATUS

(57) Abstract

Multiple colors are used in connection with one or more encoded symbols to increase the information density of the encoded symbols. The multiple colors can be used to form linearly independent encoded symbols that are overlayed on top of each other to form a composite encoded symbol. The linearly independent encoded symbols may be used to designate different types of information, or can designate separate levels of information in which certain levels can have restricted access. Alternatively, the multiple colors can be used to form a single linearly dependent encoded symbol in which the selected combination of colors defines data states of corresponding elements of a one or two dimensional matrix. Registration marks are used to insure proper print registration of the differently colored elements to insure linear dependency. In either embodiment, the colors can be distinguished using electro–optical imaging techniques.



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MULTI-COLORED SYMBOLOGY METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to encoded symbols, and more particularly, to a method and apparatus using multiple colors for increasing the information density of encoded symbols.

2. Description of Related Art

It is common within the data collection industry to encode information about an object into an encoded symbol, print the encoded symbol on a label, and attach the label to the object. Alternatively, the encoded symbol can be printed directly onto the object. An electro-optical imaging system can then be used to read the encoded symbol and translate it back into the original information. Systems of this nature are commonly used in various applications, such as inventory control, point-of-sale identification or logistical tracking systems. It is also common to encode information about a person into an encoded symbol, and print or attach the encoded symbol to an identification card or the like. Systems of this nature are commonly used in applications such as security systems.

The term "symbology" refers to a set of rules that define the manner in which information is encoded into an encoded symbol. More specifically, a symbology typically defines a set of "code words" each of which represents one piece of information in the information set to be encoded, and each code word is defined as a particular arrangement of pattern elements. Typically, the information to be encoded consists of alpha-numeric characters, and each code word represents one alpha-numeric character. The information to be encoded may, however, comprise other types of symbols such as

graphical symbols.

Traditionally, the automatic data collection industry has used predominantly one-dimensional symbologies. In a one-dimensional symbology, each code word consists of a one-dimensional arrangement of pattern elements, and an encoded symbol consists of a one-dimensional arrangement of code words. A bar code is a well known example of a one-dimensional symbology. Each code word in a bar code symbology consists of a one-dimensional arrangement of parallel bars and spaces. Numerous well known one-dimensional symbologies exist, including Codabar, Code 39, and Code 93.

A trend in the automatic data collection industry has been to encode increasingly larger amounts of information into an encoded symbol. Similarly, the number of encoded symbols being attached to a single object has been increasing, where each encoded symbol encodes different types of information about the object. For example, two encoded symbols might be attached to a package, such as one encoded symbol encoding shipping information about the package, and the other encoded symbol encoding receiving information about the package. Notwithstanding these benefits, a drawback of increasing the amount of information encoded into an encoded symbol is that the physical size of the encoded symbol also increases. Likewise, attaching multiple encoded symbols onto a single object increases the overall size of the area of the object covered by encoded symbols. Therefore, as the amount of information being encoded into encoded symbols has increased, a need to increase the information density of encoded symbols has become increasingly acute.

One known method of increasing the information density of encoded symbols is to utilize a two-dimensional symbology. In a two-dimensional symbology, an encoded symbol may consist of a two-dimensional arrangement of code words, and each code word may be

defined by a two-dimensional arrangement of pattern elements. Two-dimensional symbologies permit a greater amount of information to be encoded in the same amount of space previously occupied by a one-dimensional symbology. Numerous well-known two-dimensional symbologies exist, including Codablock, PDF417, Code One, Maxicode, Vericode and Data Matrix.

Even though two-dimensional symbologies represent a substantial increase in data density over one-dimensional symbologies, there is still a need to further increase the data density beyond the capacity of conventional two-dimensional symbologies. Accordingly, a critical need exists for a symbology that achieves greater data density than conventional two-dimensional symbologies.

SUMMARY OF THE INVENTION

According to the teachings of the present invention, multiple colors are used in connection with one or more encoded symbols to increase the information density of the encoded symbols. The multiple colors can be used to form linearly independent encoded symbols that are overlayed on top of each other to form a composite encoded symbol. Alternatively, the multiple colors can be used to form a single linearly dependent encoded symbol in which the selected combination of colors defines data states of corresponding elements of a one or two-dimensional matrix. In either embodiment, the colors can be distinguished using electro-optical imaging techniques.

More particularly, in an embodiment of the present invention, a plurality of linearly independent encoded symbols are combined into an aggregate encoded symbol in which different colors are used to denote different types of data. A plurality of distinct encoded symbols are generated wherein each of the encoded symbols comprises individual elements arranged in a pattern indicative of data encoded therein. Each of the plurality of encoded

symbols are assigned a unique color corresponding to a unique type of data. An aggregate encoded symbol is formed by printing each of the encoded symbols on top of each other in the corresponding unique colors.

In another embodiment of the present invention, a plurality of linearly independent encoded symbols are combined into an aggregate encoded symbol having multiple levels of data encoding. A plurality of distinct encoded symbols are generated wherein each of the encoded symbols comprises individual elements arranged in a pattern indicative of data encoded therein. Each of the plurality of encoded symbols are assigned a unique color, wherein one of the colors is readable only by a first type of imaging device, and the other colors are readable by both the first and a second type of imaging device. An aggregate encoded symbol is formed by printing each of the encoded symbols on top of each other in the corresponding unique colors. A subordinate level user using the first type of imaging device can only read the encoded symbol in the first color, while a supervisory level user using the second type of imaging device can read each of the encoded symbols.

In yet another embodiment of the present invention, data is encoded into a matrix of elements utilizing a combination of zero or more colors in individual ones of the elements. The combination of colors defines the data encoded therein, wherein each one of the elements can encode a plurality of unique data states depending on the assigned combination of colors. A composite encoded symbol comprising the matrix of elements is printed in accordance with the assigned combinations of colors. The matrix may comprise either a one-dimensional matrix in which the elements further comprise bars, or a two-dimensional matrix in which the elements further comprise cells. Unlike the previous two embodiments, the elements of the matrix are linearly dependent such that the relative position of the colored cells defines the data

state encoded in the cells. In an example in which up to three colors are assigned, eight possible data states can be encoded into each one of the elements. Registration elements are printed in each respective one of the colors with the registration elements being positionally dependent upon ones of the elements having corresponding colors. The registration elements permit calibration of an imaging device to the colors and positions of matrix elements.

A more complete understanding of the present invention will be afforded to those skilled in the art, as well as a realization of additional advantages and objects thereof, by a consideration of the following detailed description of the preferred embodiment. Reference will be made to the appended sheets of drawings which will first be described briefly.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1a-1c illustrates two superimposed encoded symbols;

Fig. 2 illustrates an exemplary embodiment of a system for reading superimposed encoded symbols;

Fig. 3 illustrates an alternative embodiment of a system for reading superimposed encoded symbols; and

Figs. 4a and 4b illustrate a multi-colored two-dimensional encoded symbol.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention uses colors to increase the information density of encoded symbols. In one aspect of the present invention, multiple encoded symbols are printed in an overlapping manner, and each encoded symbol is printed in a distinct color. In another aspect of the invention, multiple colors are used to encode elements that compose an encoded symbol. In the detailed description that follows, like element numerals are used to describe like elements illustrated in one or more

figures.

Referring first to Figs. 1a-1c, an exemplary process for printing superimposed encoded symbols is illustrated. Initially, a first encoded symbol 102 (see Fig. 1a) is printed on a label (not shown) in a first color. The first encoded symbol 102 has a plurality of bar elements 102a-102c printed with the first color (illustrated as cross-hatching) against an unprinted background. Next, a second encoded symbol 104 (see Fig. 1b) is printed on the label (not shown) such that it is at least partially superimposed on the first encoded symbol 102. The second encoded symbol 104 has a plurality of bar elements 104a-104d printed in a second color (illustrated as stippling) that is distinct from the first color. A composite encoded symbol 106 is thus formed from the combination of the first and second encoded symbols 102, 104. The composite encoded symbol 106 thus has regions in which the bar elements from each of the first and second encoded symbols 102, 104 overlap, as well as other regions in which the bar elements are individually visible, and yet other regions in which no bar elements are present. The printed label may then be attached to an object (not shown).

Preferably, the color of each encoded symbol is selected from a predefined group consisting of the three additive primary colors (red, blue and yellow) or a predefined group consisting of the three subtractive primary colors (cyan, magenta and yellow). As known in the art, the additive primary colors combine to produce different colored regions when the respective bar elements are overlapping, such that overlapping red and blue bars would produce a violet region, overlapping blue and yellow bars would produce a green region, and overlapping red and yellow bars would produce an orange region. Similarly, the subtractive primary colors also combine to produce different colored regions when the respective bar elements are overlapping, such that

overlapping cyan and magenta bars would produce a blue region, overlapping magenta and yellow bars would produce a red region, and overlapping yellow and cyan bars would produce a green region. It should be appreciated that the selected colors are not limited to the primary additive and subtractive groups, but may be selected from any predefined group having any number of colors as long as each color in the group has a sufficiently well defined and narrow absorption profile so that the color can be separated from the other colors in the group by using optical filtering techniques.

The above described printing process is most advantageously used when multiple encoded symbols are printed on or attached to a single object. For example, four encoded symbols might be attached to a manufactured product, each encoding one of the following types of information: a) the serial number of the product; b) the date on which the product was manufactured; c) the part number of the product; and d) the manufacturing batch number of the product. In such a case, all four encoded symbols could be printed in an overlapping manner and each in a different color in accordance with the above described printing process.

It should be appreciated that the above described process of printing superimposed encoded symbols is independent of the particular type of symbology used to encode the encoded symbols, and thus can be used to print both one-dimensional and two-dimensional encoded symbols. Accordingly, the term "encoded symbol," as used herein, includes encoded symbols produced using any type of one-dimensional or two-dimensional symbology.

Referring next to Fig. 2, a block diagram of an electro-optical imaging system for reading superimposed encoded symbols is illustrated. A light source (not shown) illuminates the exemplary encoded symbols 102, 104. Light reflects off of the encoded symbols 102, 104 and onto an optical device 202, which focuses the

reflected light onto a filter 204 and an optical imager 206. The filter 204 comprises at least one filtering element for each color in which one of the superimposed encoded symbols is printed. In the exemplary embodiment illustrated in Fig. 2, the filtering element 204 comprises two filtering elements 204a, 204b. One of those filtering elements 204a corresponds to a color of one of the superimposed encoded symbols 102, and the other filtering element 204b corresponds to a color of the other superimposed encoded symbol 104. A filtering element "corresponds" to the color of an encoded symbol if the filtering element allows light having the color of the encoded symbol to pass while blocking light having the colors of the other encoded symbols. For example, the filtering element 204a allows light having the color of the encoded symbol 102 to pass, but blocks light having the color of the encoded symbol 104. Likewise, the filtering element 204b allows light having the color of the encoded symbol 104 to pass, but blocks light having the color of the encoded symbol 102.

In the exemplary embodiment illustrated in Fig. 2, the filter 204 is movable such that one of the filtering elements can be selectively placed between the optical device 202 and the optical imager 206. As shown in Fig. 2, when the filter 204 is moved such that the filtering element 204b corresponding to the color of the encoded symbol 104 is placed between the optical device 202 and the optical imager 206, light having the color of the encoded symbol 104 passes through the filter 204 and onto the optical imager 206. Light having the color of the encoded symbol 102 is blocked by the filter 204 and consequently does not reach the optical imager 206. Thus, only light corresponding to the encoded symbol 104 reaches the optical imager 206. The optical imager 206 converts the received light into a plurality of electrical signals that correspond to the intensity of the received light. The plurality of electrical signals

are then digitized.

An optical imager suitable for use in the present invention may comprise a charge-coupled device (CCD). Typically, a CCD comprises a one-dimensional or two-dimensional array of adjacent photodiodes with each one of the photodiodes defining a distinct picture element (or pixel) of the array. It should be noted that the array of the CCD imaging element is not limited to any particular pattern. For example, the array can be arranged in the usual order of linear rows and columns; or, the array can be arranged in a diamond pattern in which the rows are linear and the columns are offset in a regular fashion; or, the array can be arranged in any other pattern in which the photodiodes are ordered relative to each other. Each photodiode of the CCD array generates a voltage that represents the intensity of the light reflected onto that particular photodiode. The CCD array is scanned electronically by activating the individual photodiodes in a sequential manner in order to produce an output signal containing the voltage levels from each photodiode. The detected voltage levels are then converted to binary data values.

After the optical imager 206 converts the received light into binary data values, the binary data values are transmitted to an image memory 208 that temporarily stores the data. The image memory 208 typically comprises a semiconductor-based random access memory (RAM), and can be provided by conventional dynamic RAM (DRAM) devices. The image memory 208 permits an image from the optical imager 206 to be captured. Specifically, the binary data values produced by the CCD array are transferred into the image memory 208 and each particular data value is stored in a corresponding memory cell of the image memory.

The exemplary imaging system illustrated in Fig. 2 further comprises a microprocessor 210 and a program memory 212. The microprocessor 210 controls one or more

operations of the imaging system. The program memory 212 is coupled to the microprocessor 210 and contains an instruction set, e.g., software or firmware, that is executed in a sequential manner by the microprocessor. The software defines one or more operations of the imaging system. For example, the software may control operation of the illumination device (not shown), decode the data stored in the image memory 208, and/or display the decoded data.

As known in the art, the program memory 28 is provided by conventional semiconductor based read only memory (ROM) devices. Such ROM devices are non-volatile, and permit the stored instructions to remain in storage within the devices even after electrical power is removed. It should be apparent that the functions performed by the stored program may also be accomplished by traditional hard-wired logic circuits, although software systems are generally preferred due to their relative simplicity, adaptability to change, and low cost. It should also be apparent that the ROM devices may further be erasable or programmable, so that modifications or revisions to the software can be implemented as desired. Moreover, other permanent storage media can be utilized as the program memory 212, such as magnetic or optical disks.

The entire imaging system, including the optical device 202, the filter 204, the optical imager 206, the image memory 208, the microprocessor 210 and the program memory 212 may be contained within a single unit. Alternatively, the elements may be distributed, such as with the optical device 202, filter 204 and optical imager 206 disposed in a remote device, and the other elements disposed in a central unit. This way, an operator can utilize a simple, lightweight unit such as a hand-held device, that transmits image data to the central unit for decoding. The decoded data may then be transmitted to an attached computer, stored locally for

later transfer, or forwarded to an application program resident within the imaging system itself.

Referring next to Fig. 3, a block diagram of an alternative embodiment of an electro-optical imaging system for reading multiple overlapping encoded symbols is illustrated. This alternative embodiment includes an optical device 202, a microprocessor 210 and a program memory 212 that are similar to like elements described above with respect to Fig. 2.

In this alternative embodiment, the optical device focuses light reflected off of the encoded symbols 102, 104 onto a beam splitter 302, which splits the light received from the optical device into a plurality of light beams. The exemplary beam splitter 302 illustrated in Fig. 3 splits the light received from the optical device 202 into two light beams. The first beam is directed through a first filter 304 and onto a first optical imager 306, and the second beam is directed through a second filter 308 and onto a second optical imager 310. The filters 304, 308 function in a manner similar to the filters 204a, 204b described above with respect to Fig. 2. Likewise both optical imagers 306, 310 function in a manner similar to the optical imager 206 described above with respect to Fig. 2. Binary data generated by the first optical imager 306 is stored in a first image memory 314, and binary data generated by the second optical imager 310 is stored in a second image memory 312. Both image memories 312, 314 are similar to the image memory 208 described above in connection with Fig. 2.

From the foregoing discussion, it should be appreciated that the encoded symbols 102, 104 of Figs. 1a-1c each comprise distinct symbols that are decoded separately. In this regard, the linear position of each one of the encoded symbols 102, 104 is entirely independent from the other, and the symbols are printed in the overlapping manner simply to conserve space and

imaging resources. As will be further described below, it is also possible to dispose the encoded symbols in a linearly dependent manner such that the relative position of the differently colored bar elements of the encoded symbols is used to convey additional information.

In view of the linearly independent nature of the encoded symbols illustrated in Figs. 1a-1c, the symbols could alternatively be printed such that they do not overlap at all. Such a printing arrangement would still reduce the overall size of each encoded symbol because there would be no need to encode information identifying the type of information represented by the symbol, but instead, the color of the symbol can be used to denote a certain type of information. For example, a red symbol might encode receiving information of a package, and a yellow symbol might encode shipping information of the package. No portion of the red symbol would need to include an identification of the type of encoded information as being receiving information. Likewise, no portion of the yellow symbol would need to include an identification of the type of encoded information as being shipping information.

In an alternative application of the encoded symbols illustrated in Figs. 1a-1c, the symbols can be used to convey two different levels of information. A subordinate level of information could be encoded into the first symbol 102 using a color that is visible to the color-readable electro-optical imaging systems as described above with respect to Figs. 2 and 3, as well as by a conventional electro-optical imaging system used to scan black-and-white encoded symbols. Such a conventional electro-optical imaging systems may utilize one or two-dimensional CCD arrays as a sensor, or may comprise a scanning laser device having red-colored laser light provided by a laser diode. Cyan is an example of a color that would be visible to both types of imaging systems using CCD arrays, and would also be readable by

the red-colored laser light of a laser diode. A supervisory level of information could be encoded into the second symbol 104 using a color that is visible to the color-readable electro-optical imaging systems, but not visible to the conventional electro-optical imaging systems. Yellow is an example of a color that would only be visible to the color-readable electro-optical imaging systems. In accordance with this embodiment, subordinate level users would be provided with conventional electro-optical imaging systems, and supervisory level users would be provided with the color-readable electro-optical imaging systems. Thus, only the supervisory level users would be able to read the second symbol 104, which could contain information to which restricted access is required.

Although the exemplary encoded symbols illustrated in Figs. 1a-1c are one-dimensional bar codes, it is anticipated that the encoded symbols could also be two-dimensional encoded symbols. In addition, while only two overlapping encoded symbols are illustrated in Figs. 1a-1c, it is anticipated that three or more encoded symbols could be similarly printed in an overlapping manner, as long as each is printed in a distinct color.

Referring now to Figs. 4a and 4b, a technique of utilizing multiple colors to increase the information density of a single encoded symbol is illustrated. An exemplary two-dimensional encoded symbol is illustrated generally at 400 in Fig. 4a, and comprises an array of individual cells 404 bounded by a rectangular boundary region 402. A combination of zero or more colors selected from the predefined group of colors can be printed in each cell 404. In the example shown in Fig. 4b, the predefined group of colors comprises three colors 404a (illustrated as ascending cross-hatching), 404b (illustrated as descending cross-hatching), 404c (illustrated as stippling). Consequently, each cell 404 in the exemplary encoded symbol 400 has eight possible

states, wherein the presence of a color in the cell is construed as a binary one and the absence of the color in the cell is construed as a binary zero, as shown graphically in Fig. 4b. As illustrated in Fig. 4a, the plurality of cells 404 are encoded with the three colors 404a-404c in an exemplary manner, such that some of the cells have no encoding, some are encoded by one of the colors, some are encoded by two of the colors, and some are encoded with all three colors. Preferably, the predefined group of colors used to encode an encoded symbol such as the exemplary symbol illustrated in Fig. 4a consists of either the three additive primary colors or the three primary subtractive colors. It should also be appreciated, however, that the predefined group of colors may be comprised of any number of colors as long as each color has a sufficiently well defined and narrow absorption profile so as to be separable from the other colors in the group using optical filtering techniques.

A multicolored encoded symbol such as that illustrated in Fig. 4a can be read utilizing an electro-optical imaging system similar to that illustrated in Fig. 3. The beam splitter 302 would split the light received from the optical device 202 into as many beams as there are colors in the predefined group of colors used to encode the symbol. A filter, optical imager and image memory would be provided for each beam created by the beam splitter 302. The information encoded into each cell 404 can be recovered by detecting the colors 404a-404c in relation to the cell location.

Unlike the encoded symbols 102, 104, it should be appreciated that the colors used in the cells 404 of the two-dimensional encoded symbol 400 are linearly dependent. Particularly, the precise location of each colored cell in relation to the other colored cells is used to convey the information contained in the encoded symbol. Accordingly, it is necessary that proper registration of the colored cells be achieved during

printing.

Since proper print registration may be difficult to achieve in practice, an alternative embodiment allows the encoded symbol to be properly decoded in spite of any print misregistration. According to the alternative embodiment, the two-dimensional encoded symbol 400 is provided with registration marks 405, 406, 407 disposed within the boundary region 402. The registration marks 405, 406, 407 are printed with each of the respective cell colors 404a, 404b, 404c. Ideally, the registration marks 405-407 should be perfectly aligned together. By comparing the relative placement of the registration marks 405-407, the electro-optical imaging system can detect a magnitude and direction of any relative misregistration of each corresponding color, and use that information to properly orient the detected colors to the appropriate cell locations.

Moreover, the registration marks 405-407 also serve to calibrate the electro-optical imaging system to the colors which may have changed over time due to environmental factors. Specifically, the electro-optical imaging system can self calibrate to the wavelength of light reflected by the registration marks, and use those calibrated values in decoding the colored cells of the encoded symbol 400. Another advantage of the registration marks 405-407, is that it permits a variable number of colors to be used with a single encoded symbol format. The electro-optical imaging system would be able to identify the number of colors used in an encoded symbol by interpreting the registration marks disposed with the encoded symbol 400. For example, an encoded symbol using two separate colors would be provided with two corresponding registration marks.

Although the exemplary encoded symbol 400 illustrated in Fig. 4a is a two-dimensional symbol, the illustrated technique could also be used with a one-dimensional symbol, such as a bar code. For example, the

bars in a bar code could comprise one or more colors selected from a predefined group of colors. The linearly dependent one-dimensional symbol may include a start code disposed at the beginning of the symbol that could be adapted to include registration bar elements, to provide the same function as the registration marks described above.

Having thus described several alternative embodiments of the present invention, it should be apparent to those skilled in the art that certain advantages have been achieved. It should also be appreciated that various modifications, adaptations, and alternative embodiments thereof may be made within the scope and spirit of the present invention. The invention is limited only by the following claims.

CLAIMS

What is Claimed is:

1. A method of combining a plurality of encoded symbols into an aggregate encoded symbol comprising the steps of:

generating a plurality of distinct encoded symbols, wherein each of said encoded symbols comprises individual elements arranged in a pattern indicative of data encoded therein;

assigning to each of said plurality of encoded symbols a unique color corresponding to a unique type of data; and

forming an aggregate encoded symbol by printing each of said encoded symbols on top of each other in the corresponding unique colors.

2. The method of Claim 1, wherein said forming step further comprises overlaying each of said encoded symbols in a linearly independent manner.

3. The method of Claim 1 in which three encoded symbols are generated, and wherein said assigned colors include cyan, magenta and yellow.

4. The method of Claim 1 in which three encoded symbols are generated, and wherein said assigned colors include red, blue and yellow.

5. A printed label having an aggregate encoded symbol printed in accordance with the method of Claim 1.

6. A method of combining a plurality of encoded symbols into an aggregate encoded symbol comprising the steps of:

generating a plurality of distinct encoded symbols, wherein each of said encoded symbols comprises individual elements arranged in a pattern indicative of data encoded therein;

assigning to each of said plurality of encoded symbols a unique color, wherein a first one of said colors is readable only by a first type of imaging device, and a second one of said colors is readable by both a first and a second type of imaging device; and

forming an aggregate encoded symbol by printing each of said encoded symbols on top of each other in the corresponding unique colors.

7. The method of Claim 6, wherein said forming step further comprises overlaying each of said encoded symbols in a linearly independent manner.

8. The method of Claim 6 in which three encoded symbols are generated, and wherein said assigned colors include cyan, magenta and yellow.

9. The method of Claim 6, wherein said first type of imaging device is adapted to detect each said unique color, and said second type of imaging device is adapted to detect only said second one of said colors.

10. The method of Claim 9, wherein said second one of said colors is cyan, and said second type of imaging device comprises a red-colored laser light scanning device.

11. The method of Claim 6, wherein two encoded symbols are generated in which said first one of said colors is selected from magenta and yellow, and said second one of said colors is cyan.

12. The method of Claim 11, wherein said first type of imaging device comprises an electro-optical imaging device adapted to detect magenta, yellow and cyan, and said second type of imaging device comprises an electro-optical imaging device adapted only to detect cyan.

13. The method of Claim 6, wherein said encoded symbol assigned said color readable by only the first type of imaging device is encoded with supervisory level data.

14. A printed label having an aggregate encoded symbol printed in accordance with the method of Claim 6.

15. A data encoding system comprising:

means for generating a plurality of distinct encoded symbols, wherein each of said encoded symbols comprises individual elements arranged in a pattern indicative of data encoded therein;

means for forming an aggregate encoded symbol by printing each of said encoded symbols on top of each other in respective different colors;

first means for optically imaging said aggregate encoded symbol and resolving said aggregate encoded symbol into a first one of said plurality of distinct encoded symbols; and

second means for optically imaging said aggregate encoded symbol and resolving said aggregate encoded symbol into each one of said plurality of distinct encoded symbols.

16. The system of Claim 15, wherein said first imaging means further comprises means for decoding said first one of said plurality of distinct encoded symbols to recover said data encoded therein.

17. The system of Claim 15, wherein said second imaging means further comprises means for decoding each one of said plurality of distinct encoded symbols to recover said data encoded therein.

18. The system of Claim 15, wherein said forming means further comprises means for overlaying each of said encoded symbols in a linearly independent manner.

19. The system of Claim 15 in which three encoded symbols are generated, and wherein said colors include cyan, magenta and yellow.

20. The system of Claim 15 in which three encoded symbols are generated, and wherein said colors include red, blue and yellow.

21. The system of Claim 15, wherein two encoded symbols are generated in which a first one of said encoded symbols is printed a color selected from magenta and yellow, and a second one of said encoded symbols is printed cyan.

22. A method of encoding data comprising the steps of:

defining a matrix of elements;

assigning a combination of zero or more colors to individual ones of said elements in a manner indicative of data encoded therein, wherein each one of said elements can encode a plurality of unique data states depending on the assigned combination of colors; and

printing a composite encoded symbol comprising said matrix of elements in accordance with said assigned combinations of colors.

23. The method of Claim 22, wherein said matrix further comprises a one-dimensional matrix, and said elements further comprises bars.

24. The method of Claim 22, wherein said matrix further comprises a two-dimensional matrix, and said elements further comprises cells.

25. The method of Claim 22, wherein said matrix of elements are linearly dependent.

26. The method of Claim 22, wherein said colors include cyan, magenta and yellow.

27. The method of Claim 22, wherein said colors include red, blue and yellow.

28. The method of Claim 22 in which up to three colors are assigned, whereby eight possible data states can be encoded into each of said elements.

29. The method of Claim 22, further comprising the step of printing registration elements in each respective one of said colors, said registration elements being positionally dependent upon ones of said elements having corresponding colors.

30. The method of Claim 29, further comprising the step of calibrating an imaging device to said colors of said registration elements.

31. The method of Claim 29, further comprising the step of calibrating an imaging device to locations of said registration elements.

32. The method of Claim 29, further comprising the step of calibrating an imaging device to a number of said colors of said combination of colors.

33. A data encoding system comprising:

means for generating a matrix of elements each having a combination of zero or more colors selected in a manner indicative of data encoded therein, wherein each one of said elements comprises one of a plurality of unique data states depending on the assigned combination of colors;

means for printing a composite encoded symbol comprising said matrix of elements in accordance with said assigned combinations of colors;

means for optically imaging said composite encoded symbol to resolve each said combination of colors for said elements; and

means for decoding each said combination of colors to recover said data encoded therein.

34. The system of Claim 33, wherein said matrix further comprises a one-dimensional matrix, and said elements further comprises bars.

35. The system of Claim 33, wherein said matrix further comprises a two-dimensional matrix, and said elements further comprises cells.

36. The system of Claim 33, wherein said matrix of elements are linearly dependent.

37. The system of Claim 33, wherein said combination of colors comprises cyan, magenta and yellow.

38. The system of Claim 33, wherein said combination of colors comprises red, blue and yellow.

39. The system of Claim 33 in which up to three colors are assigned, whereby eight possible data states can be encoded into each of said elements.

40. The system of Claim 33, further comprising means for printing registration elements in each respective one of said colors, said registration elements being positionally dependent upon ones of said elements having corresponding colors.

41. The system of Claim 40, wherein said imaging means further comprises means for calibrating said decoding means to said colors of said registration elements.

42. The system of Claim 40, wherein said imaging means further comprises means for calibrating said decoding means to locations of said registration elements.

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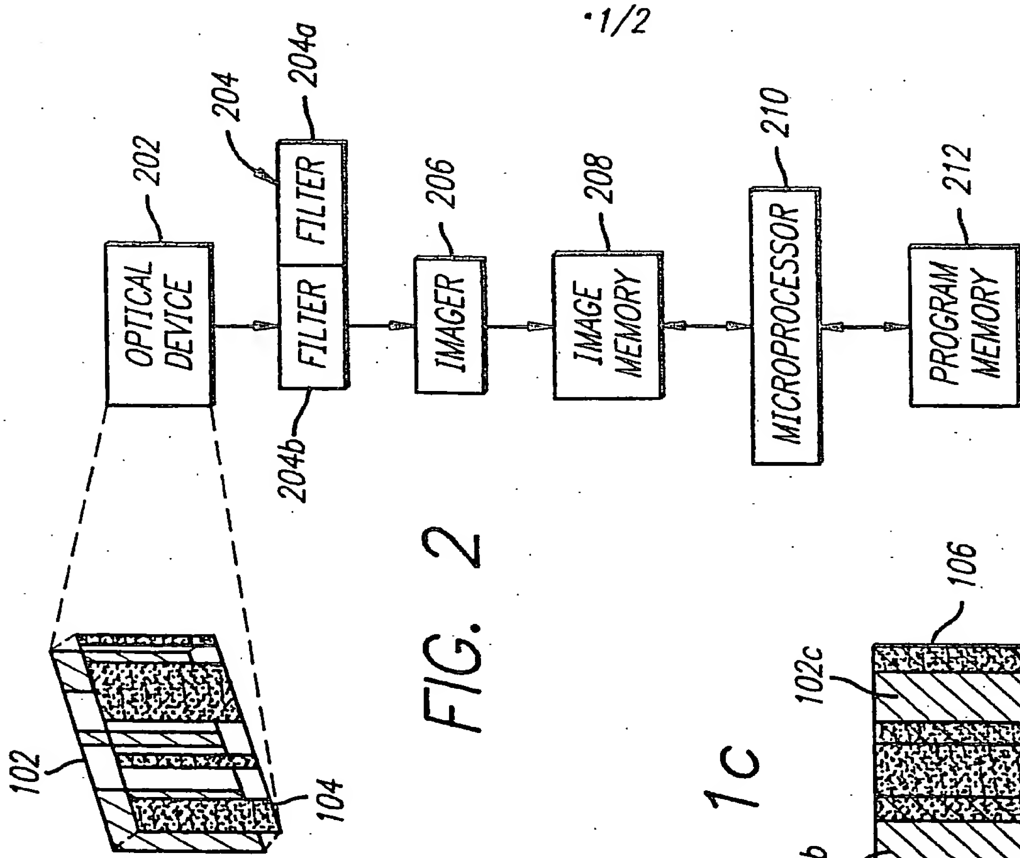

FIG. 2

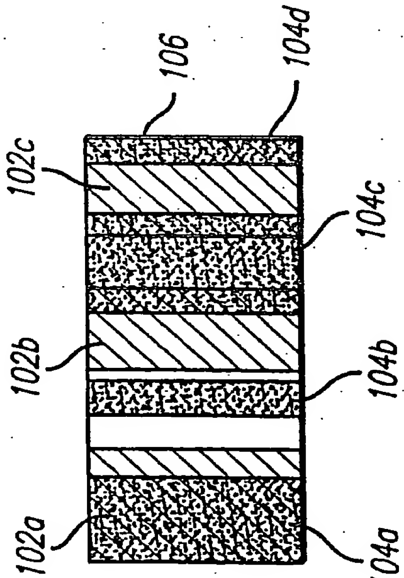

FIG. 1c

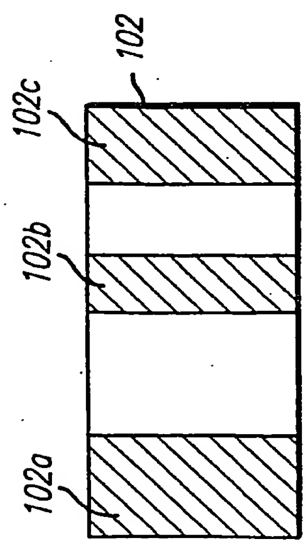

FIG. 1a

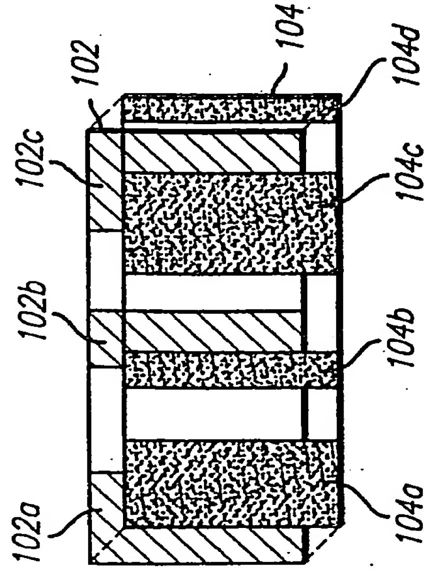

FIG. 1b

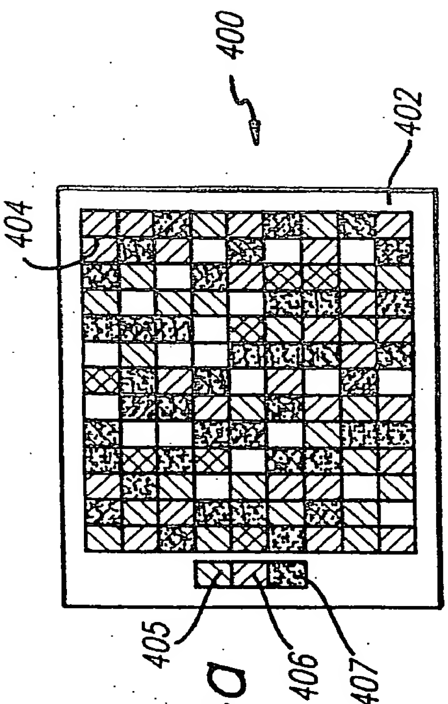

FIG. 4a

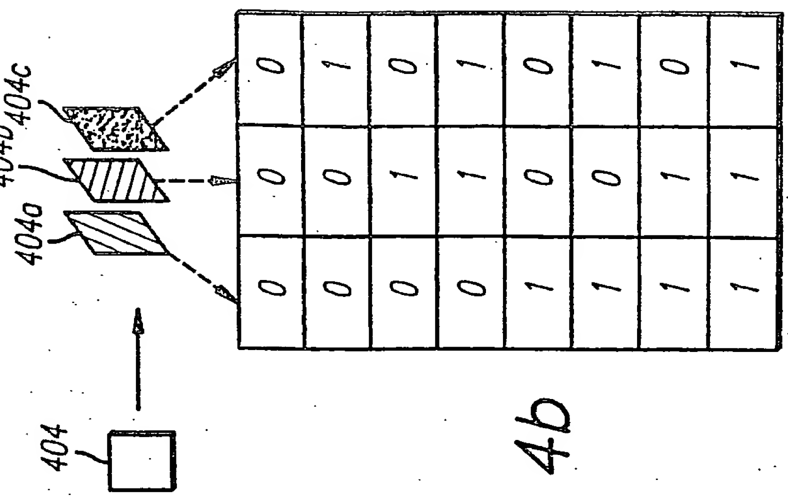

FIG. 4b

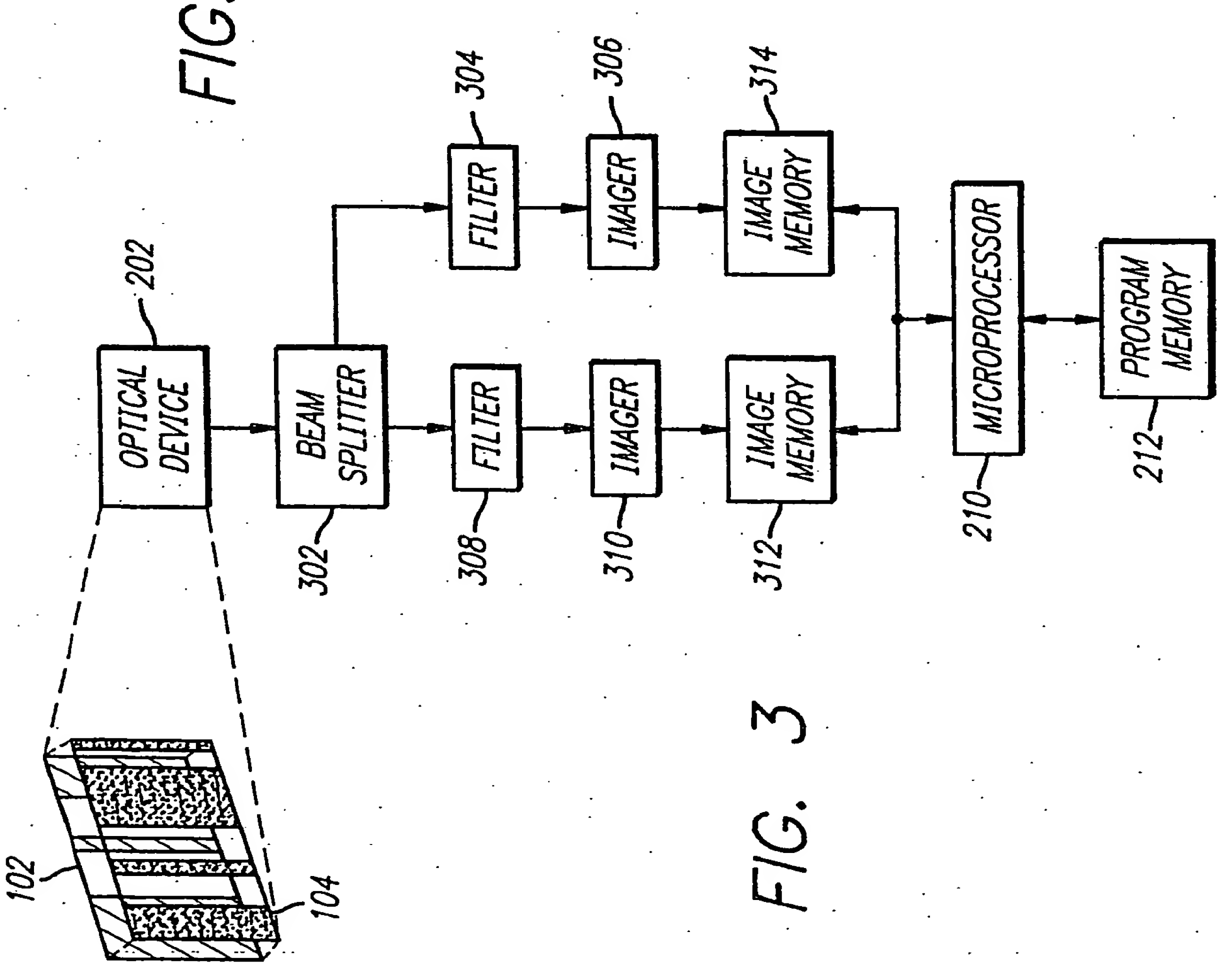

FIG. 3